



The Future of Communications

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Anywhere, Anytime, Any Device

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The future is unwired

Analysts predict that by 2005 there will be 700 million mobile handsets and over 80 million WLANs in use world-wide, and nearly 13 million wireless home networks in place in the United States. Explosive growth of wireless networks and devices will have a huge impact on the core network itself. The network equipment infrastructure, converged devices and valuable services that are enabling the unwired future represent an enormous opportunity for computing and communication companies and the businesses and consumers they serve.

For thirty-five years, Intel has been changing the way the world computes. Through industry-leading silicon design and manufacturing, standards-based technology and product building blocks, and collaboration with industry, academia, and government, Intel is accelerating convergence and changing the way the world communicates. As communications and computing converge, Intel is uniquely positioned to accelerate the shift to a new world of services and information access anywhere, any time, on any device.



"The convergence of computing and communications will bring a new level of productivity to business, reducing costs and extending the reach of communications across the globe, opening up new opportunities on a scale we can't imagine today. Intel is committed to accelerating toward this future, through continued technology advancements and close collaboration with industry and governments worldwide."

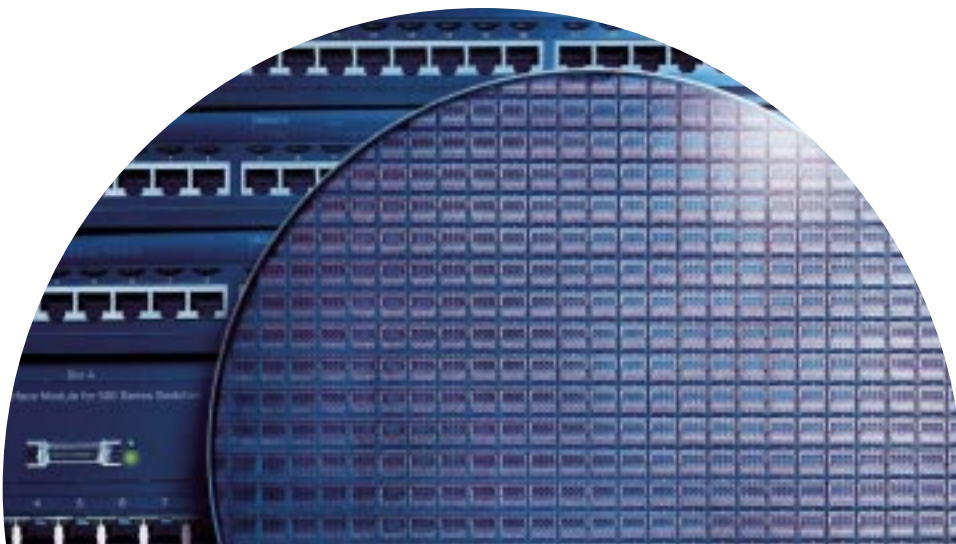
Pat Gelsinger

Senior Vice President and
Chief Technology Officer
Intel Corporation

Commitment to communications technology and a converged future

Intel is highly committed to accelerating the converged future: our research and development budget reached \$4 billion in 2002 and remains steady at a time when many companies are scaling back in this area. Our world class investment has led to a constant stream of communications solutions dating back 30 years from co-authoring the Ethernet specification to development of low cost modems and a wide range of other telecom, data, and voice communications building blocks.

Intel® technologies enable the communications industry to capitalize on the wireless revolution. We are the world's largest supplier of silicon used in communications products – including flash memory, processors, and chipsets for cell phones and handsets – a leading provider of Ethernet products, and a major provider of WAN and LAN technologies. For the communications industry, Intel's extension and expansion of Moore's Law to communications technologies means innovative products and services, faster time to market, lower overall cost, and flexible yet stable systems.



Designing and Manufacturing Communications Silicon

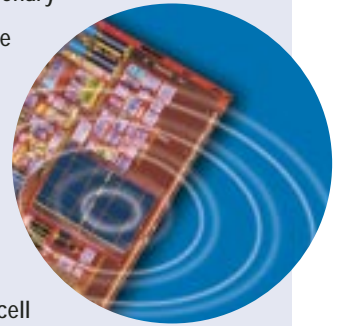
Device and equipment manufacturers are challenged to bring innovative products to market faster while simultaneously lowering costs. In response, Intel scientists are expanding Moore's law to the development of low-cost communications devices based on our silicon technology and volume manufacturing expertise. As a result, manufacturers are able to cost-effectively produce wireless and optical communications devices that are smaller and consume less power while outperforming existing products:

- Intel's industry-leading **90nm manufacturing process** employs advanced materials such as strained silicon to produce today's smallest, highest performing CMOS transistors in volume. When combined with mixed signal capability, our 90nm process enables the production of communication silicon with higher clock frequencies, performance, and increased transistor density for integrating new capabilities and features.
- Our wireless "**Internet on a chip**" is the first of its kind to bring high-end features to mainstream mobile phones through integration of a wireless module, application processor and flash memory on a single chip. The result is unparalleled performance and application headroom for voice and computation-intensive data applications for next generation handsets and mobile devices.
- Intel's **silicon photonics** research is exploring optical building blocks that route, detect and manipulate light in silicon. An example is the silicon optical modulator, which converts electrical ones and zeros to optical signals capable of traveling tens of kilometers. Such devices could extend these silicon technologies into cost-effective new market segments such as high-speed chip-to-chip optical interconnects or optical networking applications.
- We are well on our way to producing the necessary RF passives, multi-band analog front end (AFE) and reusable digital baseband elements for an all-CMOS **agile radio** solution. Intel recently demonstrated a prototype of an all-digital-CMOS 10 GHz agile-RF frequency synthesizer based on a 5 GHz CMOS voltage-controlled oscillator (VCO) that features phase noise specified as -120 dBc at a 1 MHz offset. This is one of several developments aimed at realizing the vision of Radio Free Intel (see sidebar).



Radio Free Intel

About more than just the integration of radio communications capability into our processors and chipsets, this visionary Intel initiative will make it easy and inexpensive to enable flexible wireless connectivity in every conceivable type of product – from PDAs, notebooks and cell phones to consumer electronics, appliances, and even clothing and furniture. Making wireless connectivity cheap and ubiquitous will help drive new revenue opportunities for the communications industry by offering business and consumers greater access to more useful information and services anytime, anywhere on any device they choose.



To meet the requirements and challenges inherent in realizing this ambitious vision, Radio Free Intel is focused on providing low-cost, low power silicon radio building blocks, collaborative development of a comprehensive adaptive radio architecture, and global adoption of appropriate and favorable standards and regulatory policies. By combining our silicon technology and manufacturing expertise with research and development efforts spanning key application segments, technologies, and industry enablement issues, Radio Free Intel will enable a future where ubiquitous wireless connectivity is as central to our lives as the automobile is today.

Standards-based Building Blocks

Service providers strive to raise average revenue per user (ARPU) while controlling costs associated with infrastructure investments. To help service providers reach and benefit from new markets more quickly with device-aware and network-aware content and services, Intel supplies a wide array of standards-based building blocks and modular platforms that provide flexibility, extend time in market, and lower overall system costs:

Seamless wireless communication

- Intel is developing a standards-based **adaptive radio architecture** that will support multiple radio protocols over multiple frequency bands – such as 802.11 Wireless Fidelity (Wi-Fi*), Wireless Code-Division Multiple Access (W-CDMA), Bluetooth*, and 802.15.3a Ultra Wide Band (UWB) wireless networks. Using a common flexible hardware base that includes a scalable mesh of heterogeneous processing elements and smart antenna systems, Intel's solution will enable smaller, more power efficient devices with improved spectrum usage, throughput and range.



“Proprietary network equipment solutions will no longer work. Carriers need modular, robust systems built on standard components to significantly lower capital expenditures and operating costs. Intel is helping by providing the building block components that are the foundation of the modular network.”

Eric Mentzer
Vice President,
Chief Technical Officer
Intel Communications Group
Intel Corporation

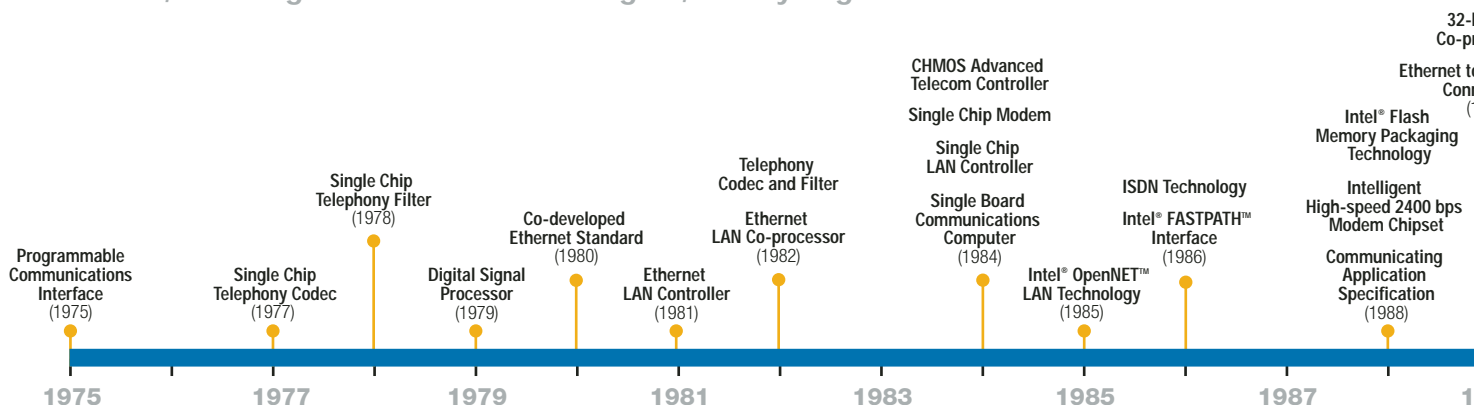
- Developers are using Intel concept and **reference designs** to develop multi-network, power-efficient handsets supporting advanced applications, mobile identification, and security features. The Universal Communicator is one such concept showcasing a high-performance, multimedia handheld with General Packet Radio Services (GPRS) and Wireless Fidelity (Wi-Fi) connectivity and power management technologies for maximum battery life.

Flexible, scalable solutions for modular networks

- The convergence of communications and computing technologies is catalyzing the development and adoption of modular platforms. Intel's **modular communications platforms** enable reduced expenditure, solution flexibility, faster time-to-market, and greater choice of vendors. Through a growing ecosystem of standards-based suppliers, Intel provides reusable development and deployment platforms including carrier-grade operating systems, high-availability middleware APIs, and scalable I/O interconnects.

Intel Leadership in Communication

Silicon, Building Blocks and Technologies, Catalyzing Standards





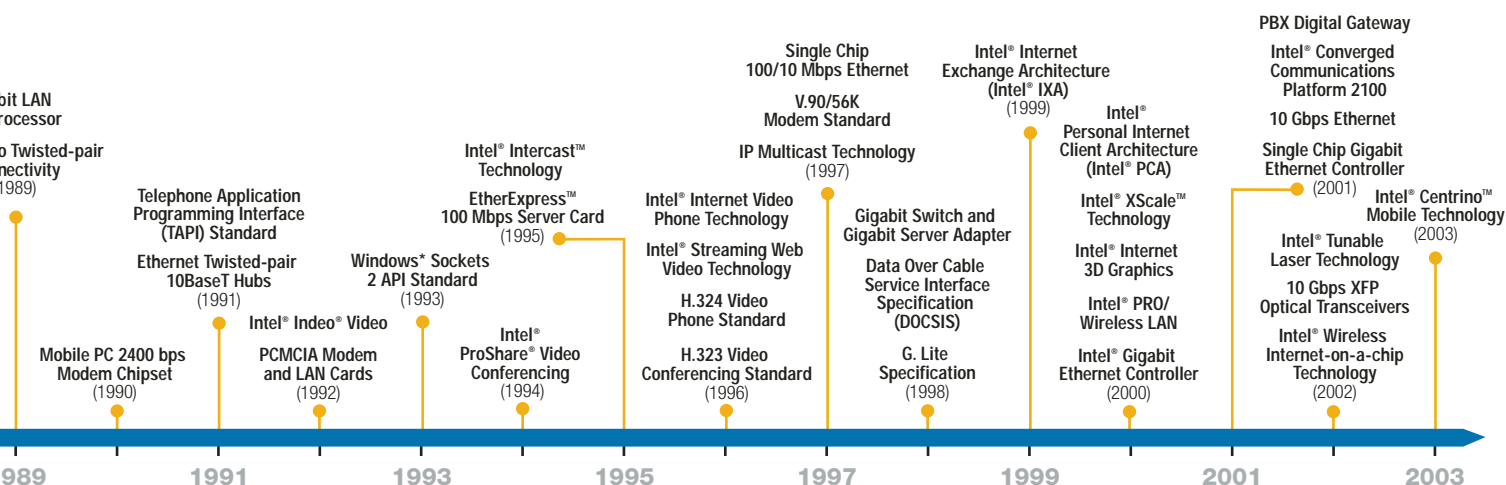
- Intel is committed to align its communications silicon and platform with **PCI Express* architecture** and **Advanced Switching** based on **PCI Express technology**. Both technologies allow communications and embedded applications to take advantage of the lowest cost, widely available, compute industry matured PCI Express intellectual property and comprehensive validation of interoperability. Computing is an integral part of nearly all communications functions for data, control plane and management processing in communications equipment, so it is advantageous for the PCI Express specification to maintain 100% PCI software compatibility. The Advanced Switching specification defines tunneling capability that helps preserve your investment in application software built upon legacy interconnects making the transition process smooth. PCI Express and Advanced Switching architectures will be the common interconnects for both the communications and computing industry for the next decade, providing excellent performance, advanced features, cost economies and interoperability.
- With industry-leading performance, extended life-cycle support, and low-voltage implementations, embedded **Intel® architecture processors** meet the demand for compute-intensive services and control processing in communications infrastructure equipment. By combining advanced multiprocessing

features and low power Intel® XScale™ technology with an easy to use programming framework, **Intel® Internet Exchange Architecture (IXA)** network processors provide extensive programmability

and fast packet processing for communications applications at line rates up to OC-192/10 Gbps.

Application and service deployment

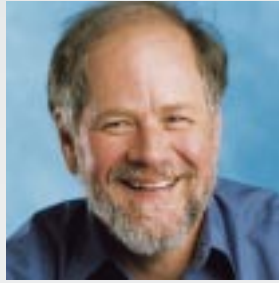
- Intel is working on standardized APIs for developers in order to enable **location-aware computing**, customizing the information and services available to users depending on their location. We are also developing enhanced device **characterization and provisioning** – matching applications and services to unique clients and utilizing device capabilities and state – technologies and standards to ensure the best possible end-user experience.
- **Manageable Identity technologies** enable users of Intel platforms to easily access any network and service with a trusted and appropriate virtual identity, which can be easily transferred between the user's devices and the wireless networks within their environment. The first instantiation of the technology will allow wireless notebook users to seamlessly access the SIM (Subscriber Identity Module) information on a cellular device to securely connect to carrier provided Wi-Fi networks.



Catalyzing the Industry

Enterprises seek higher productivity from their communications investments and a lower total cost of ownership. With an active role in more than 30 communications-related standards bodies, Intel plays an integral role in the development of communications infrastructure, mobility and wireless technologies and standards. By incorporating standards in our own products, Intel provides the interoperability and stability that lower costs and simplify system management:

- Through Intel's **Wireless Verification Program (WVP)** more than 50 wireless internet service providers in 18 countries have verified thousands of Wi-Fi hotspots around the globe, building awareness for wireless ubiquity and driving demand for new communications services. Likewise, **Intel® Centrino™ mobile technology** provides wireless connectivity for users on the go without additional equipment and manual configuring.
- Intel supports a network of industry players in the development of wireless standards-based technology products. To catalyze industry wireless development activity, Intel chairs or holds leadership positions in several wireless **standards bodies** such as the IEEE* 802.11 working group for Wi-Fi and IEEE 802.15.3 for UWB and wireless Universal Serial Bus (USB), Worldwide Interoperability for Microwave Access* (WiMax) – certifying compatibility for 802.16.a – and the Bluetooth* Special Interest Group.

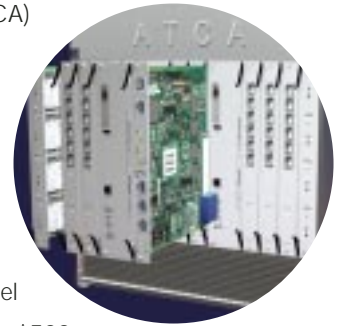


“Intel plays an integral role in promoting open wireless communications standards. In addition to sitting on all of the major standards bodies and serving as chair of several, we actively engage in regulatory discussions with the U.S. government and are frequently invited to advise governments around the world about emerging technology standards. Our holistic view of computing and communications gives us a solid understanding of how to drive standards that will ensure interoperability across a broad spectrum of devices.”

Kevin Kahn
Intel Fellow,
Corporate Technology Group
Director, Communications
and Interconnect Technology

- To overcome technical and regulatory barriers, such as the potential frequency interference caused by ultra wideband (UWB) and radio spectrum licensing challenges, Intel collaborates with academia, government and a number of **industry groups** including the European Telecommunications Standards Institute* (ETSI), Internet Engineering Task Force* (IETF), IPv6 Forum*, Open Mobile Alliance* (OMA), Universal Plug and Play Forum* (UPnP) and the PCI Industrial Computer Manufacturer's Group* which is developing the Advanced Telecom Compute Architecture (ATCA) specification.

- In addition to ongoing investments in internal research and development, Intel has established a **\$500 million communications fund** for targeted investments in companies exploring advanced communications related technologies. Since its inception in 1999, the Fund has invested in more than 100 companies in 17 countries. Intel recently allocated **\$150 million to investments in Wi-Fi** and the value chain supporting it.



Capitalizing on the Future – Today

As the communications industry approaches the unwired future, we face important opportunities to launch new services, reach new customers, and access new markets at home and around the world. Communications equipment and services providers that build flexibility and openness into their devices, systems, and infrastructure today with standards-based, integrated, modular technologies from Intel will be in a strong position to compete tomorrow.



With our world-class research and development capabilities, communications experience, and track record of leadership, Intel is enabling the industry to capitalize on the opportunities that convergence presents – reducing costs, increasing performance, speeding time to market, and uncovering new sources of growth and profitability – and leading the way toward the vision of a converged future embracing *anywhere, anytime, any device*.

Take advantage of Intel's hard work. Learn more about Intel research and development initiatives in communications. Understand how Intel technology advances and industry enablement activities create opportunities for your enterprise and engage with us on related research projects. Maximize your success and accelerate time to market by using Intel architecture-based platforms and tools.

Intel. Accelerating the Convergence of Computing and Communications. **Together, we can build the unwired future.**

Exploratory Research in Communication – Sensor Networks

Intel's research work is enabling self-organizing wireless **sensor networks** that monitor and relay critical information

about the environment around them in a broad range of applications in-



cluding agriculture, conservation and industrial production. By integrating low-power processing, storage and wireless communications capabilities, Intel® mote technology provides the tiny, self-contained, battery-powered computing and communication components upon which these sensor networks are based. To aid in the deployment of these prototype sensor hardware platforms, Intel Research, in collaboration with its UC Berkeley-affiliated research lab, is developing and promoting advanced packet processing technologies and software specifications for multi-hop sensor networks through open-source software such as TinyOS* and TinyDB*.

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